If f_2 is the higher cut off freq. then,

$$\frac{1}{\sqrt{2}} = \frac{1}{\sqrt{1+\left(\frac{2\pi f C_a h_{ie} R_c}{h_{ie}+R_c}\right)^2}}$$

$$\Rightarrow \frac{1}{2} = \frac{1}{1+\left(\frac{2\pi f C_a h_{ie} R_c}{h_{ie}+R_c}\right)^2}$$

$$\Rightarrow 1+\left(\frac{2\pi f C_a h_{ie} R_c}{h_{ie}+R_c}\right)^2 = 2$$

$$\Rightarrow \frac{2\pi f C_a h_{ie} R_c}{h_{ie}+R_c} = 1$$

$$\Rightarrow 2\pi f C_a h_{ie} R_c = h_{ie}+R_c$$

$$\therefore f_2 = \frac{h_{ie}+R_c}{2\pi h_{ie} C_a R_c} \quad \text{— (B)}$$

From eq (B)

$$|A_{vm}| = \frac{|A_{vm}|}{\sqrt{1+\left(f/f_2\right)^2}}$$

$$= \frac{|A_{vm}|}{\sqrt{1+\tan^2\theta_n}}$$

where,

$\tan\theta_n = f/f_2$

$\theta_n = \tan^{-1}(f/f_2)$

* Output and Input Impedance.

Calculated;

Input impedance; RC coupled amplifier ckt:

$Z_{in} = R_1 // R_2 // Z_b \quad [Z_b = h_{ie}]$

Output impedance: O/P impedance of transistor

$$Z_o = 1/h_{oe} = \infty$$

O/P. impedance of RC coupled amp (2 stage)

$$Z_{out} = 1/h_{oe} // R_{C2} \simeq R_{C2}$$

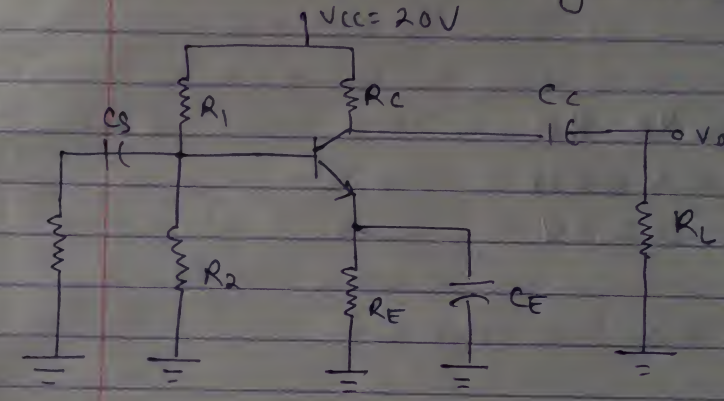
* Advantage of RC coupled Amplifier, excellent freq. Response, low cost, less weight and space occupied.

Disadvantage:-
low voltage and power gain, tendency to noise impedance matching is low.

Application:
- widely used: voltage amplifier.

Distortions:-

(Q) Determine lower cut off frequency for a network of figure below using the following parameters C_S = 10uf, C_E = 20uf, C_C = 1uf, R_S = 1K, R_1 = 40K, R_2 = 10K, R_E = 2K, R_C = 4K, R_L = 2.2K, β = 100, r_o = ∞, V_{CC} = 20V. also sketch the freq. response using bode Plot.



Sol":

To determine r_e dc condition we use,

$\beta R_e = 100 * 2 \gg 10 R$ (Twe)

$= 200K$

we have,

$I_E = \frac{V_E}{R_E}$

$$V_B = \frac{R_2 \cdot V_{CC}}{R_1 + R_2}$$

$$= \frac{10 * 20}{(40+10)}$$

$$= 4V$$

$$V_{BE} = V_B - V_E$$

$$0.7 = 4 = -V_E$$

$$\therefore V_E = 3.3V$$

then

$$I_E = \frac{V_E}{R_E} = \frac{3.3}{2} = 1.65mA$$

$$r_e = \frac{26mV}{I_E} = \frac{26mV}{1.65\ mA} = 15.75\Omega$$

$$\beta r_e = 100 * 15.75 = 1575\Omega$$

$$= 1.576K\Omega$$

mid band gain, $A_{VM} = \frac{V_0}{V_i}$

$$= \frac{-R_C // R_L}{r_e}$$

$$= \frac{-4 // 2.2}{15.75\Omega}$$

$$= \frac{-4 // 2.2}{0.015K}$$

$$= -14.62$$

Input impedance, $Z_i = R_i = R_1 // R_2 // \beta r_e$

$$= 40 // 10 // 1.576$$

$$= 1.31$$

$$f_{CL} = \frac{1}{2\pi (R_S + R_i) C_S}$$

$$= \frac{1}{2\pi (1 + 1.31) 10}$$

$$= \frac{1}{2\pi (1+1.31) * 1000 * 10 * 10^{-6}}$$

$$= 6.88\ Hz$$

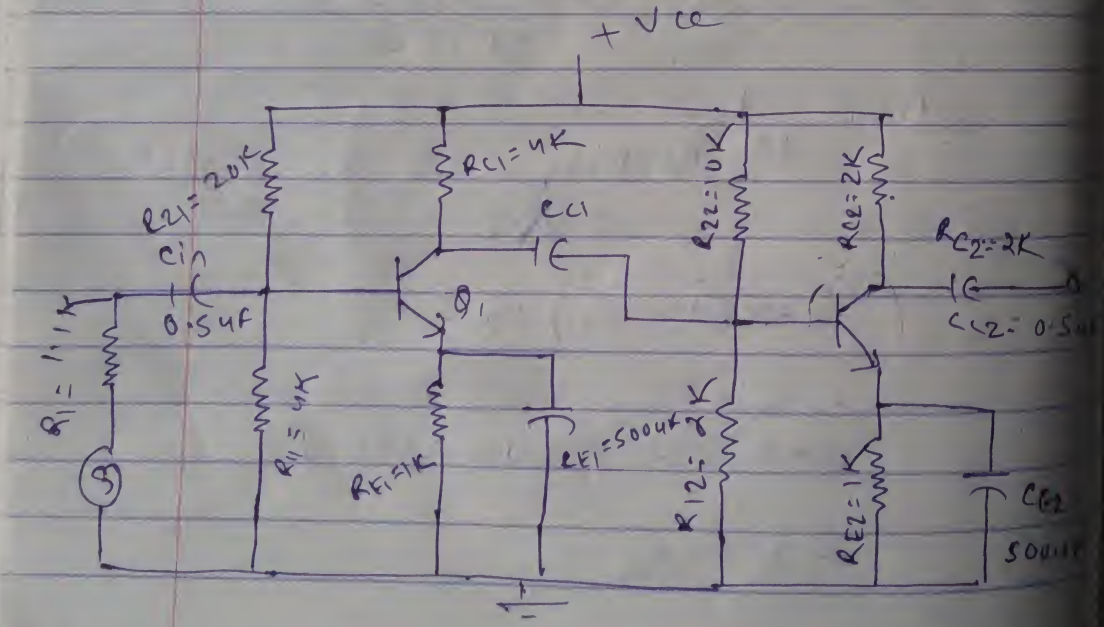
$$V_i = \frac{R_i v_s}{R_i + R_s} = \frac{V_i}{V_s} = \frac{R_i}{R_i + R_s} = \frac{12.227}{12.227 + 1} = 0.92$$

Overall voltage gain; $\frac{V_o}{V_s} = \frac{V_o}{V_i} * \frac{V_i}{V_s}$

$= -0.901 * 0.92$

$= -0.8325$

Determine input impedance, output impedance and overall voltage gain for a two stage RC coupled amp. shown below, with resistance connected across output terminals of the amp. is of 10K where hie = 1.1K hfe = 50, hre = hoe = 0



101,

$Z_b = h_{ie} + \beta h_{re}$

$= h_{ie} + 0$

$= 1.1K$

(i) $Z_{in} = R_{21} // R_{11} // Z_b$

$= 20 // 4 // 1.1$

$= 0.82 K\Omega$

o/p impedance of $Q_2 = \frac{1}{h_{oe}} = \infty$

(ii) Z_{out} : o/p impedance of the amp ckt.

$Z_{out} = 1/h_{oe} // R_{C2} \cong R_{C2} = 2K$

(iii) $A_{VS} = A_{V1} * A_{V2}$

Voltage gain of 2nd stage

$A_{V2} = -\frac{h_{fe}}{h_{ie}} (R_{C2} // R_L)$

$= -\frac{50}{1.1} (2 // 10)$

$= -75.75$

Effective load to the 1st stage,

$R_{out} = R_{C1} // R_{B2} // R_{B1} // h_{ie}$

$= 0.6\,k\Omega$

So,

V_B = base of 1st stage

$A_{V1} = \frac{-h_{fe} * R_{out}}{h_{ie}}$

$= \frac{-50 * 0.6}{1.1}$

$= -27.31$

$A_{V2} = -35.71 * -27.31$

$= 975.08$

Compute the overall voltage gain for the two stage RC coupled amplifier shown in Fig below. Assume the amplifier operates where $V_{BE} = 0.8V$ for R_1 and R_2

Solⁿ

Base voltage, V_{B2} = Voltage across $R_6 = \frac{V_{CC} \cdot R_6}{R_5 + R_6}$

$= 4V$

Emitter voltage, $V_{E2} = V_{B2} - V_{BE} = 4 - 0.8 = 3.2V$

Emitter current in R_8, $I_{E2} = \frac{V_{E2}}{R_8} = \frac{3.2V}{1K}$

$= 3.2mA$

RC for 2nd stage, $R_{C2} = \frac{2.8mV}{I_{E2}} = \frac{2.8mV}{3.2mA} = 2.8\Omega$

Z in base for 2nd stage = $R_7 // R_8 // \beta R_{C2}$

$= 100 * 2.8$

$= 280\,\Omega$

$= 2K$

input impedance for 2nd stage,

$Z_{in2} = R_5 // R_6 // z_{in}$ (base)

$= 45 // 5 // 2$

$= 1.3846 K$

Effective collector load for 2nd stage,

$R_{ac2} = R_7 // R_L$

$= 5 // 20$

$= 4K$

Voltage gain for 2nd stage;

$A_{V_2} = -\frac{R_{ac2}}{R_{C2}} = -\frac{4}{0.02}$

$= -200$

Effective collector load for 1st stage,

$R_{ac1} = R_3 // z_{in2}$

$= 5 // 1.3846$

$= 1.0842 K$

V_{B1} = Voltage across $R_2 = \frac{V_{cc} \cdot R_2}{R_2 + R_1}$

$= \frac{20 * 5}{50}$

$= 2V$

$V_{E1} = B_1 - 0.7 = 1.3V$

r_{e1} for 1st, $r_{e1} = \frac{26mV}{I_{E1}} = 20\Omega$

$= 0.02$

$A_{V1} = -\frac{R_{ac1}}{r_{e1}} = -\frac{1.0842}{0.02} = -54$

$A_{VS} = A_{V2} * A_{V1}$

$= -200 * -54$

$= 10800$

And in dB: $(A_V)_{dB} = 20 \log_{10}(10800)$

$= 80.66 dB$

Harmonic Distortion:-

% of n^{th} harmonic Distortion: $\%D_n$

$$= \frac{A_n}{A_1} * 100\%$$

where, A_n: Amplitude of n^{th} harmonic component.

A_1: Amplitude of the fundamental comp.

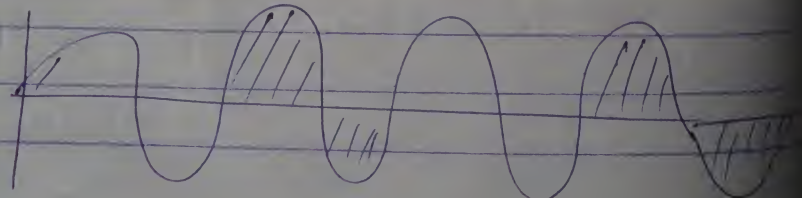
∴ The total harmonic distortion (THD)

$$\therefore \%\ THD = \sqrt{D_2^2 + D_3^2 + \dots} * 100\%$$

Note: "Distortion Analyzer" are used to measure the % THD

(Q) The principle harmonics in a certain 10V peak, 50KHz signal are the second and fourth. All other harmonics are negligible small. If the THD is 12% and the amplitude of the second harmonic is 0.5 what is the amplitude of the 60KHz harmonic?

Soln,



$$THD = \sqrt{D_2^2 + D_4^2}$$

$$\text{or, } (0.12)^2 = D_2^2 + D_4^2$$

$$\text{then, } D_2 = \frac{A_2}{A_1} = \frac{0.5}{10} = 0.05$$

$$\Rightarrow D_4^2 = (0.12)^2 - (0.05)^2$$

$$D_4 = 0.1090$$

Hence,

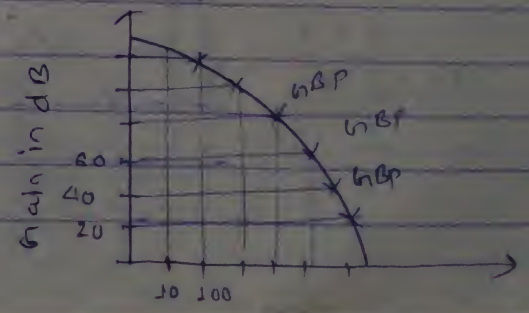
Amplitude of 40Hz signal or A_4 =

$$D_4 * A_1$$

$$= 0.1090 * 10$$

$$= 1.09\ KHz$$

Gain Bandwidth Product:



$$[B/W]_{closed\ grp} = \frac{GBP}{closed\text{-}loop\ gain}$$

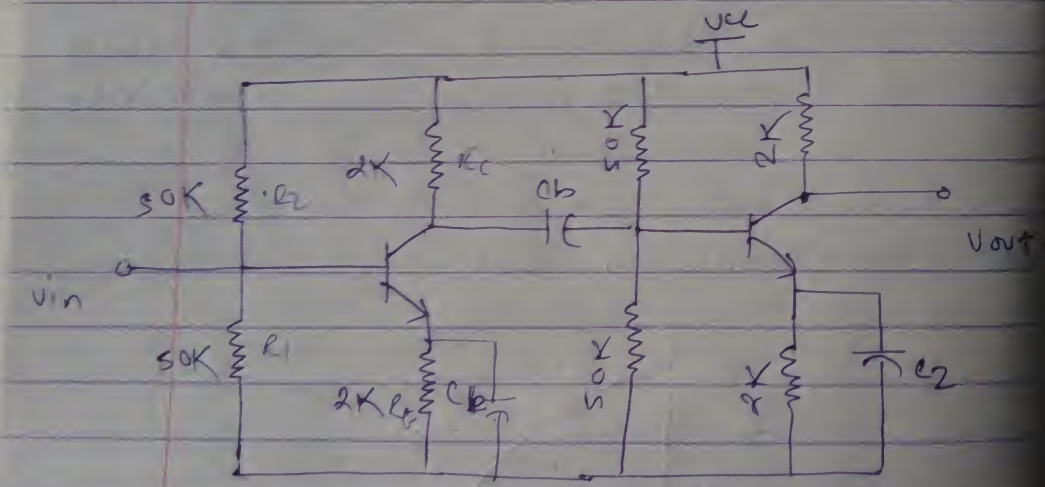
(5) The parameter of the transitor in ckt shown are $h_{fe} = 50$, $h_{ie} = 1.1\ K\Omega$, $h_{re} = h_{oe} = 0$. find

(1) mid-band gain

(2) valve of C_b necessary to give lower 3dB freqvency of 20Hz.

(3) The valve of C_b necessary to insure less than 10% tilt for a 100Hz sq. wave input.

% tilt $(P) = \frac{\pi f_1}{f}$



Soln,

(1) mid-band gain $(A_{vm}) = \frac{h_{fe} R_L}{h_{ie} + R_L}$

$$= \frac{50 * 2K}{1.1 + 2K}$$

$$= \frac{100K}{3.K}$$

$$= 33.3$$

(2) lower cut off freqveny $(f_1) = 20Hz$

$$f_1 = \frac{1}{2\pi C_b (h_{ie} + R_L)}$$

$$0.707 = \frac{1}{2\pi \times C_b (1.1 + 2)}$$

or, $20 \times 6.4 \times C_b = 1$

or, $C_b = \frac{1}{20 \times 6.4\pi}$

$C_b = 2.56\mu F$

(3) percentage tilt $(P) = 10\%$

we have,

$$P = \pi \frac{f_1}{f} \times 100\%$$

a. $10 = \pi * \frac{f_1}{100} * 100$

or, $\frac{10}{\pi} = f_1$

$\therefore f_1' = 3.18\ Hz$

Then,

$f_1' = \frac{1}{2\pi C_b (1.1+2)}$

or, $3.18 * 2\pi * C_b * 3.1 * 10^3 = 1$

or, $C_b = \frac{1}{51.93}$

$\therefore C_b = 10.14\ \mu F$

Chapter: 3

large signal Amplifier or power amplifier

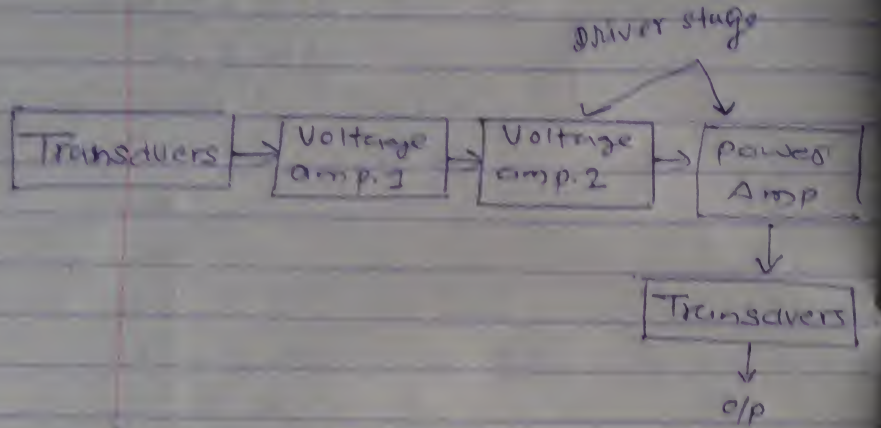


fig: Stages of practical Power Amplifiers

Voltage Amp → Driver stage → o/p stage

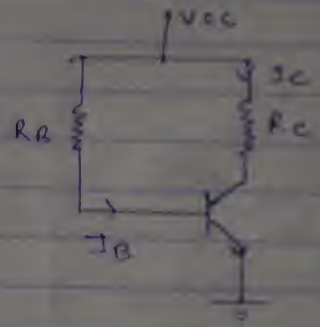
Hence, in a electric system in which voltage amplifier always precedes power amplifier. Hence, power amplifier are called large signal amplifier.

Infact, power amplifier does not directly amplify power. So, the transistors employed in the power amplifiers are called power transistor.

Features:

i) β - small (<100)
ii) Heat sink
iii) E-B junction is heavily doped.

load line Analysis:-



$V_{CC} - I_B R_B - V_{EB} = 0$

or, $V_{CC} - V_{EB} = I_B R_B$

$\therefore I_B = \frac{V_{CC} - V_{EB}}{R_B}$

or, $V_{CC} = I_B R_B + V_{EB}$

Again,

$V_{CC} - I_C R_C + V_{EC} = 0$

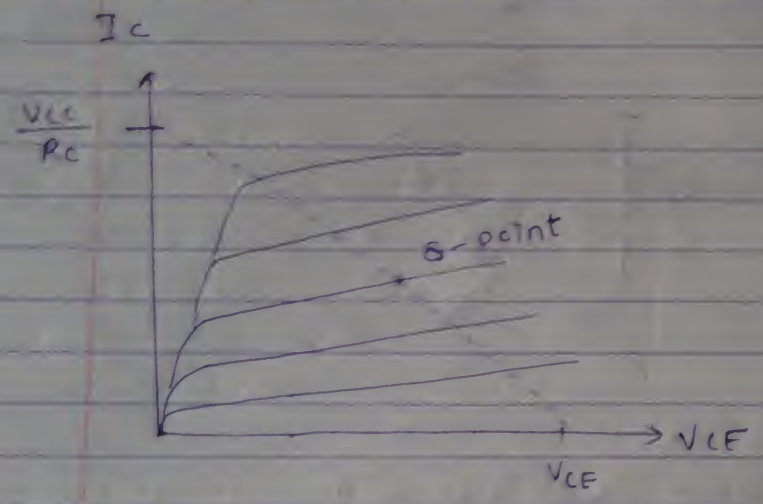
or, $V_{CC} - V_{EC} = I_C R_C$

$I_{CC} \frac{V_{CC} - V_{EC}}{R_C}$

$V_{CE} = V_{cc} - I_c R_c$

$V_{CE} = V_{CC}$ $[I_c = 0]$

$I_c = \frac{V_{cc}}{R_c}$ $[V_{CE} = 0]$



Classification of power Amplifier:-

Generally two types:-

↳ Audio power amplifier: (Also called small signal Amplifier)

20Hz - 20KHz → Audio range

↳ Radio power Amplifier: large signal power amplifier

Radio range freq: above 20KHz

Classification based on the mode of operation.

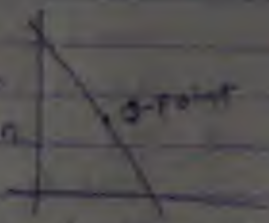
↳ class A
↳ Class B
↳ class AB
↳ class C
↳ class D

1. Class A

- operating point is fixed exactly at the centre of VCE load line. ie operation is restricted only over a small area (central region) of load line.
- o/p flows for the entire (360°) cycle of the i/p signal.

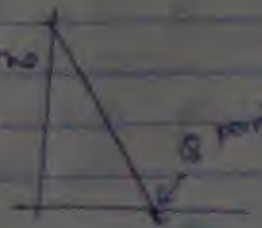
$\eta = 50\%$

- widely used in small signal amplifier.



2. Class B

→ Q point lies exactly at the cut off point.



(+ve)

→ o/p flows only for one half cycle of i/p (180°). So introduce more distortions

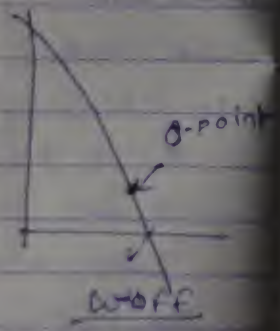
$\eta = 78.5\%$

→ Generally used for large signal amplifier

Class AB:

→ Q-point is fixed slightly above cut-off point and below central line point

→ o/p conducts for more than 180° and less than 360°

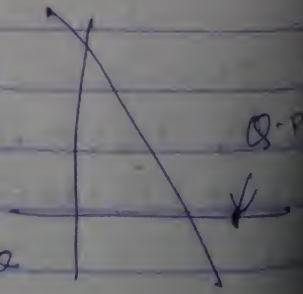


→ In order to get full o/p cycle as i/p we use push-pull combination of amplifier.

Class - C

→ Q-point lines beyond cut-off point

→ o/p conducts for less than 180° cycle



→ Used in tuned amplifier. (Radio communication)

Class D:

→ Designed to operate with digital or pulse type signal.

→ make use of sample and Hold amplifier.

→ Advantageous to recreate a complete signal from pieces of signal

η > 90%